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FACILITIES

INVESTMENTS, DISINVESTMENTS, REINVESTMENTS AND MAINTENANCE STRATEGIES (REVISED)

USDA FOREST SERVICE

R-3

CLYDE G. WELLER

SEPTEMBER 1981

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EXPERIMENT STATION

OUTLINE
Transportation Systems
Investments, Disinvestments, Reinvestments
And Maintenance Strategies

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TRANSPORTATION SYSTEMS

REGION 3

INVESTMENTS, DISINVESTMENTS, REINVESTMENTS

I. INTRODUCTION

A. History - The management, use, and protection of the resources of the National Forests are dependent on an efficient transportation system. The Federal and interstate, primary and secondary State highway systems, the Forest highway system administered by both States and counties, the county road systems, and the Forest development road and trail system administered by the Forest Service are all essential to the use and management of the National Forests.

The Forest Service is primarily concerned with the management of the Forest development road system. This system includes about 46,500 miles of roads and travelways on the National Forests. These mileages grew historically, as shown in Figure 1. The trail system including trail travelways totals 6,600 miles. (See Table 1)

In 1980, R-3's road maintenance budget was $3.37 mm, an average $72.4 per mile of road. This $72.4 per mile is an amazingly low number if no traffic used the roads. An historical plot of road maintenance dollars is shown in Figure 2. Roads and Trails constructed and added to the system historically are shown in Appendixes A, B, and C.

In 1980, the trail maintenance budget was $481,000. This amounts to $72.9 per mile. This unit cost is also low.

B. Objective - The objective of this paper is to analyze the existing situation with respect to road construction, maintenance and reconstruction, to see if a perceived road and trail maintenance problem exists.

A second objective is to evaluate the effects of the perceived disinvestment in road capital investments and propose alternative solutions.

C. Scope - This paper looked into roads and trails. Roads were divided into local, collector, and arterial roads due to great differences in uses and costs. A direct correlation can be assumed between roads and other facilities.

II. CONCLUSIONS

1. The most efficient maintenance level can be estimated to be between 2 and 4 percent of the actual value of the capital asset. Minimum Present Value Costs (PVC) occur at 2 to 3 percent, when evaluated at 4 percent and 7 1/8 percent discount rates and a 20 year reentry.

2. Maintenance of roads and trails in Region 3 is underfinanced.

3. The actual value of the road system in R-3 is approximately $765,000,000. The actual value of the trail system is about $165,000,000. The annual

operation and maintenance needs for roads and trails in Region 3 ranges from $18,500,000 to $27,000,000.

4. Maintenance funding needs for roads and trails are not different from other building type facilities. The actual value of our building type facilities in R-3 is in excess of $120,000,000 as per study for RPA 1980. Facility maintenance needs are then $2,400,000 to $3,600,000 annually.

5. Two other factors (salvage value and reentry or project life) are highly significant.

III. RECOMMENDATIONS

1. Road and trail maintenance budget in Region 3 should be at least $20,000,000 per year.

2. Trend the road maintenance budget in Region 3 up to $20,000,000 as soon as fiscally possible.

3. The facilities maintenance budget should be $120,000,000 times 3 percent or $3,600,000 per year using 1980 dollars. Trending up to this value should be done as soon as possible.

IV. ANALYSIS OF THE MANAGEMENT SITUATION

A. Definitions -

1. Disinvestment - The planned or unplanned reduction in value of a capital investment, either by selling or degradation-consumption of capital asset.

2. Reconstruction - The construction needed to bring a previous capital investment up to an original standard lost by lack of maintenance or upgrade to a standard. To construct again.

3. Maintenance - The upkeep of property, capital investment, or equipment.

4. Travelway - In this paper, a road or trail of minimal standard created by construction or use, existing but not on the road or trail inventory before 1975.

5. Road Densities - The amount of roads per unit of area of land. Expressed in miles of road per square mile of land.

6. Actual Value - Amount necessary to replace or restore a capital asset.

B. Existing System - Region 3's road inventory has varied over the years. Much of the variance has been due to management methods rather than

on the ground mileage changes. In 1975, Emergency Directive 2 directed Regions to inventory all travelways. Figure 1 shows an estimate of road mileages that were claimed on our transportation system versus actual miles. The 1977 travelway inventorying added 27,000 miles of roads with the number of roads being 32,000. The total road mileage in the Region is still approximate at 46,500 miles. A projected mileage indicates a total 80,000 miles in 2030 with current management emphasis. (See Table 1) Many of these travelway miles are unneeded, many need upgrading, and many are acceptable as is. The probable net needed road miles is 40,000. These include additional construction of new roads and obliteration of some existing roads.

Many of the existing travelways were constructed as temporary roads to service timber sales, provide for recreation, develop range improvements, and/or to serve mining claims. Most of these roads continued to be used without maintenance. In many cases, travelway use and misuse has resulted in and continues to result in resource and watershed damage and hazards to users. Some Forest areas have travelway/road densities of up to 20 miles per square mile; 15 miles of which are excessive. A probable obliteration of 15,000 miles is necessary. This 15,000 miles is approximately 25,000 acres of land. This acreage returned to production, is opposed to an additional 50,000 acres removed from production with current management.

The trail inventory which includes the travelway trails added in 1977 amount to 6,600 miles. (See Table 2) These miles are not at present considered as extensive. Many are not maintained adequately. Tables 1 and 2 show the ground transportation system by Forest.

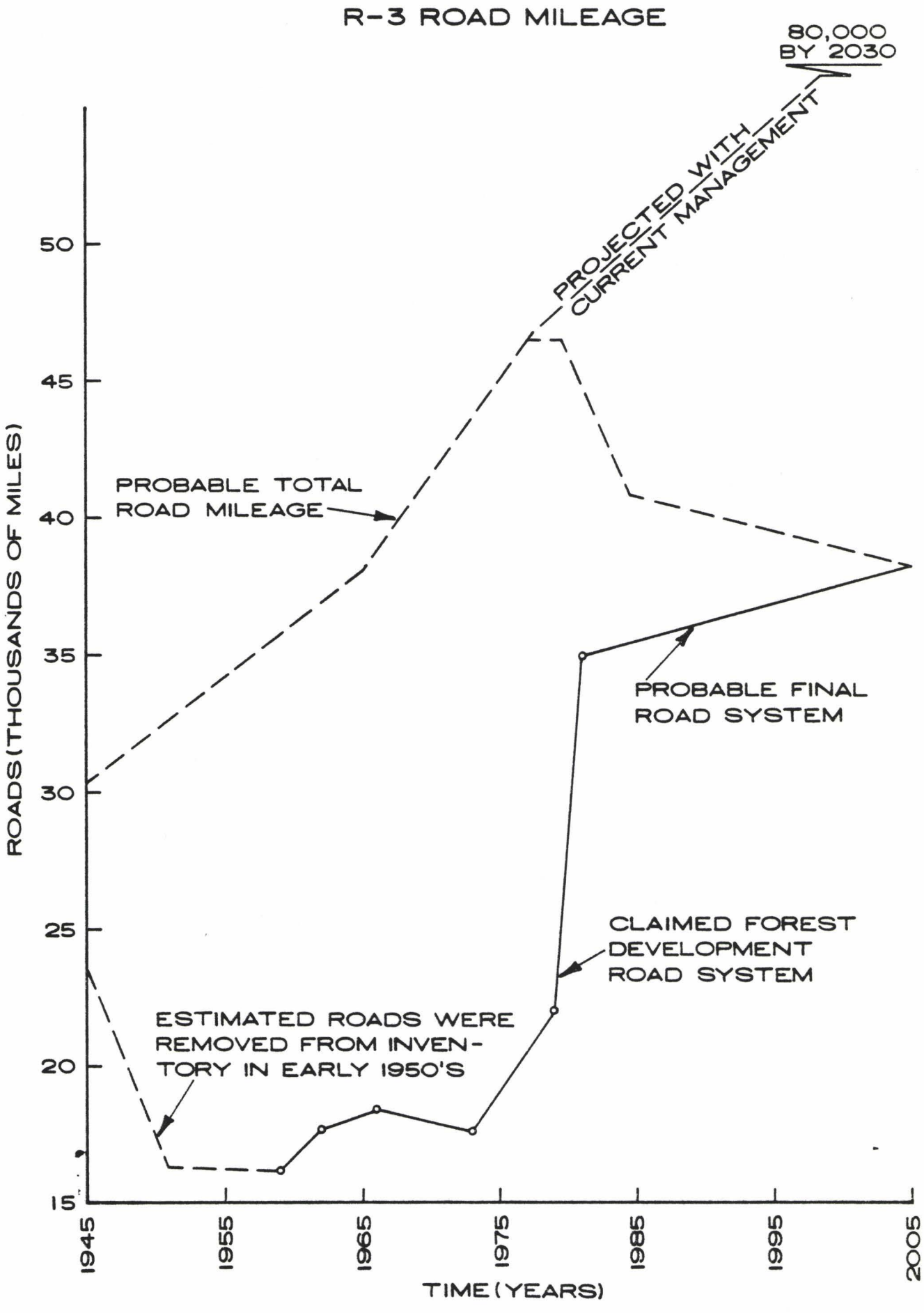

R-3 ROAD MILEAGE
80,000
BY 2030
PROJECTED WITH
CURRENT MANAGEMENT
PROBABLE TOTAL
ROAD MILEAGE
PROBABLE FINAL
ROAD SYSTEM
CLAIMED FOREST
DEVELOPMENT
ROAD SYSTEM
ESTIMATED ROADS WERE
REMOVED FROM INVEN-
TORY IN EARLY 1950'S
ROADS (THOUSANDS OF MILES)
50
45
40
35
30
25
20
15
1945
1955
1965
1975
1985
1995
2005
TIME (YEARS)

FIGURE 1.

Table 1.
Region 3 Forest Development Road System

Forest	Existing Roads Miles (1)	Travelways Miles (2)	Total 1 & 2 (Miles)
Apache-Sitgreaves	2,019	5,949	7,968
Coconino	2,324	2,677	5,001
Coronado	1,493	1,410	2,903
Kaibab	2,951	1,926	4,877
Prescott	1,284	1,153	2,437
Tonto	1,651	2,131	3,782
Arizona Total	11,722	15,246	26,968
Carson	1,342	2,813	4,155
Cibola	1,519	2,650	4,169
Gila	2,094	2,560	4,654
Lincoln	1,864	915	2,779
Santa Fe	1,586	2,155	3,741
New Mexico Total	8,405	11,093	19,498
Region Total	20,127	26,339	46,466

Table 2.
Region 3 Forest Development Trail System

Forest	System Trails Miles	Travelways Miles	Total
Apache-Sitgreaves	481	355	836
Coconino	250	79	329
Coronado	828	-	828
Kaibab	20	106	126
Prescott	318	-	318
Tonto	820	277	1,097
Arizona Total	2,717	817	3,534*
Carson	262	107	369
Cibola	353	0	353
Gila	1,279	114	1,393
Lincoln	176	71	247
Santa Fe	668	34	702
New Mexico Total	2,738	326	3,064*
GRAND TOTAL	5,455	1,143	6,598

*These are all currently listed in the 2350-9T trail inventory.

The existing value of the road and trail system is approximately $1,000,000,000. See value calculation in part D below.

C. Existing Situation

Road maintenance in Region 3 has historically been a low priority item. Road and trail maintenance has not been increased relative to the inflationary trend of the dollar, the increase in road miles and the increases of traffic. R-3's road maintenance budget is historically depicted in Figure 2. Due to inflation, traffic increases, and additional road mileage the 1980 equivalent budget to the 1954, $500,000, is conservatively $20,000,000. See Figure 3 for relative increases in road maintenance needs versus actual budget.

Currently, we are investing less than one half of a percent of actual value in road and trail maintenance. The 1980 RPA trends the road maintenance budget to 1 percent of the road system actual value annually. This is also true of the budget for other facilities (buildings and structures).

For the period 1960 through 1980, the consumer price index (CPI) for heavy construction has increased approximately 500 percent, while the overall CPI has increased less than 250 percent. (See Appendix D.)

D. Road Valuation with Respect to Time and Class

The Region 3 road system is divided into classes with estimated values as follows:

Regional Road Class Mileage and Value

	Miles		Percent of System	Unit Value $/Mile	Total Values $ MM
Arterial Roads		2,690	6	90,000	242.1
Collector Roads		5,950	13	35,000	208.3
Local Roads					
Service (open)	8,420		18	18,000	151.6
Terminal (Closed)	3,080		7	10,000	30.8
Travelways	26,500		56	*5,000	132.5
		38,000			
TOTALS		46,640	100		765.3

*This is approximately the cost of clearing for a low class road.

The present value of the road system is conservatively $765,000,000.

The trail systems actual value is approximately $25,000 per mile or (6,598 miles times $25,000 per mile) or $165,000,000.

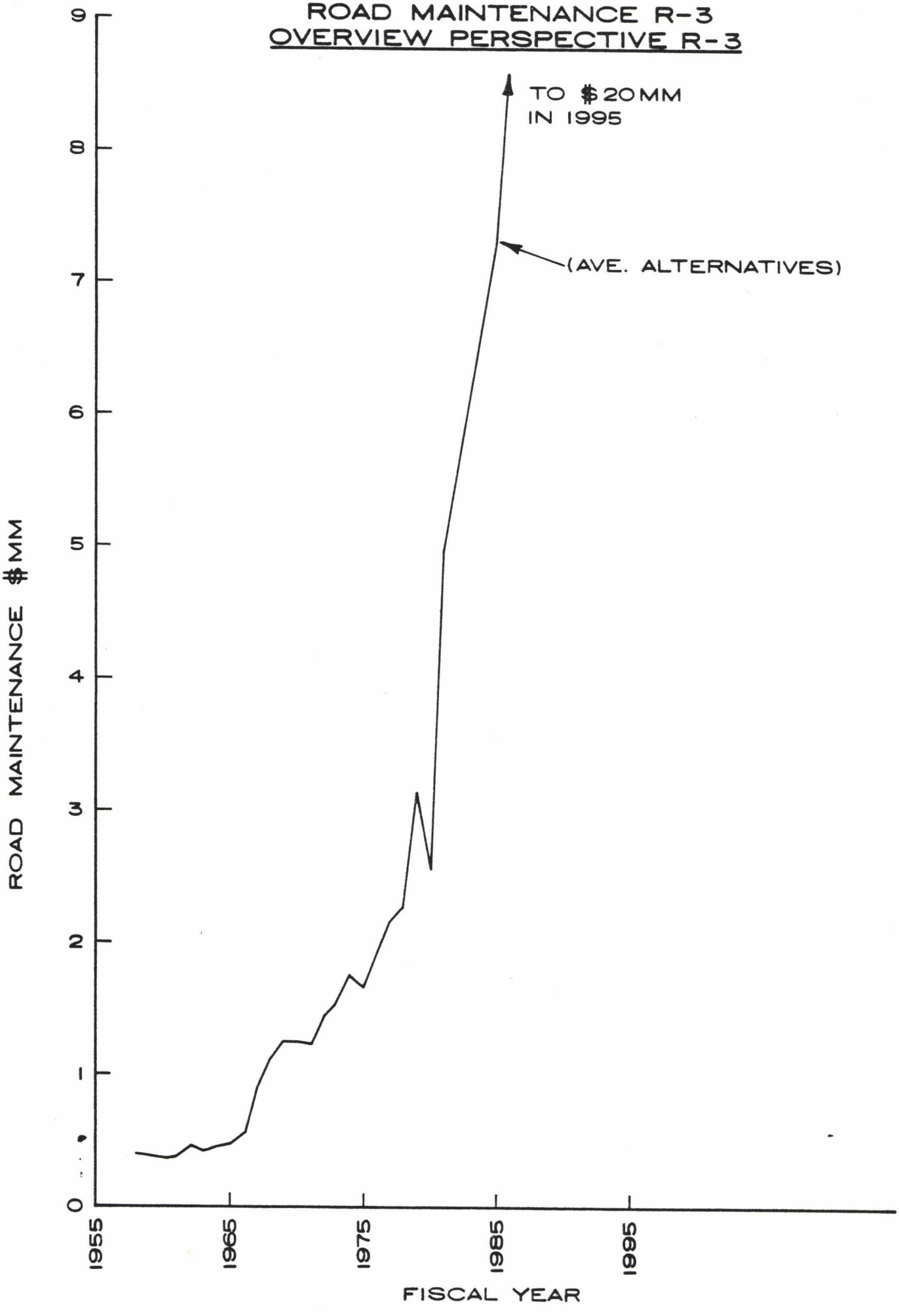

ROAD MAINTENANCE R-3
OVERVIEW PERSPECTIVE R-3
TO $20MM
IN 1995
(AVE. ALTERNATIVES)
ROAD MAINTENANCE $MM
0
1
2
3
4
5
6
7
8
9
1955
1965
1975
1985
1995
FISCAL YEAR

FIGURE 2.

R-3 ROAD MAINTENANCE ANNUAL BUDGET

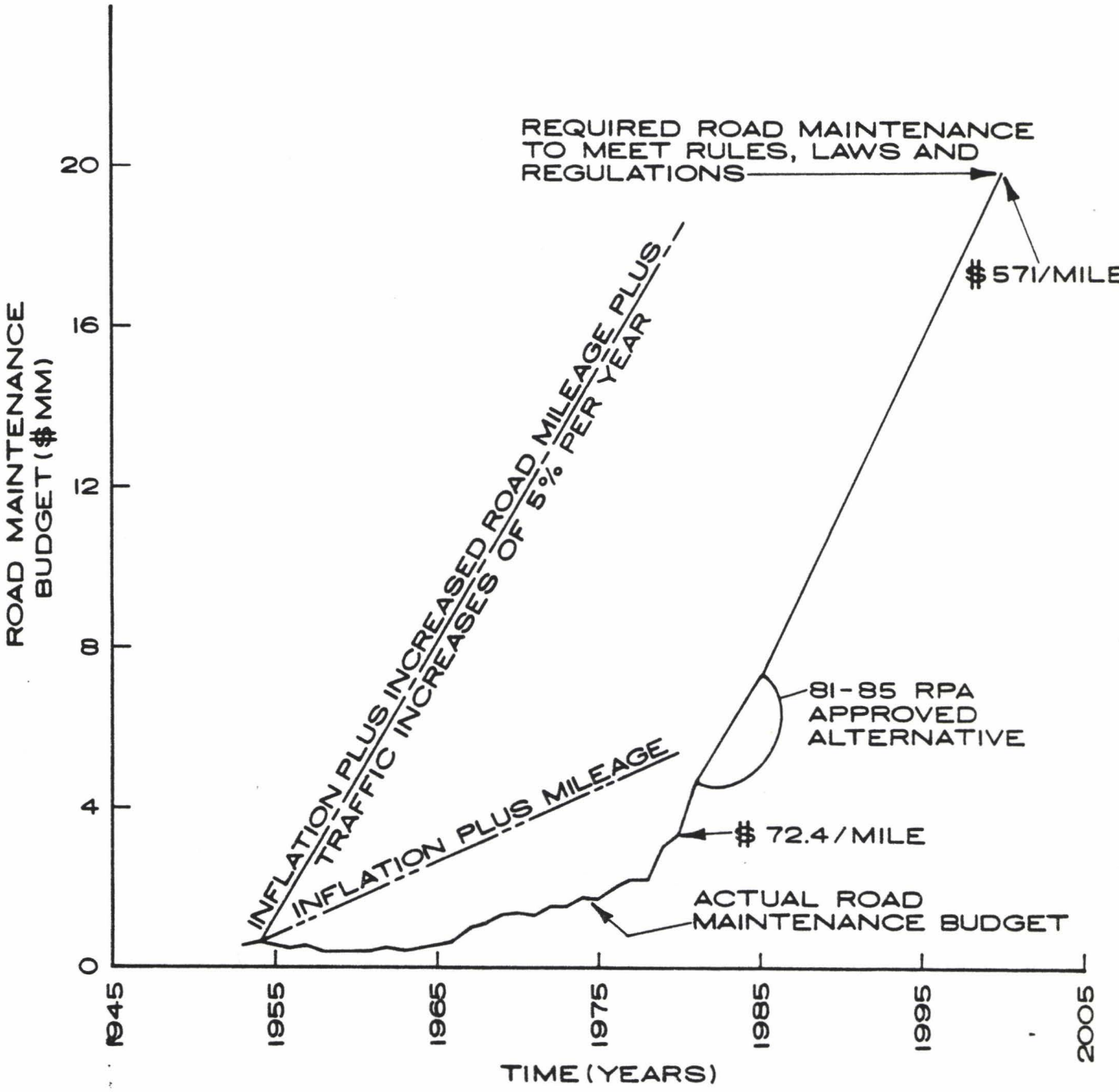


FIGURE 3.

E. Investment, Maintenance, Disinvestment, Reconstruction Relationships

In 1960, a local road in Region 3 cost about $2,000 per mile to construct. If reconstruction costs 80 percent of new construction as cost estimates are indicating, in 1980, it costs $10,000 to reconstruct that same mile of local road. Using the same assumption with current maintenance levels and inflation rates, it will cost over $50,000 to reconstruct that same mile of road for entry in year 2000. This is what actually occurs if little or no maintenance has been done. The actual value of a 1960 $2,000 per mile road is shown in Figure 4. This is also replacement value. The $2,000 per mile road will be valued at $50,000 per mile in year 2000. (See Figure 4) Currently, timber sales reconstruction of local roads is costing 80 percent of new construction on the same terrain. The reconstruction costs are high because material must be hauled to replace the surface losses, whereas, the costs of reconstruction are lower due to the initial clearing having been achieved on the existing location. The actual "real dollar" value of the 1960 $2,000 road in 1980 and 2000 is $4,000 and $8,000 respectively due to the doubling of the CPI by heavy construction.

If a road is not maintained, it deteriorates proportionately to the lack of maintenance. The question arises, "What maintenance level ($/mile/year) will maintain the investment value of the road?" Or, what maintenance level will result in a reduced present value of total costs? The purpose would be to minimize present value of costs, while maintaining a functional facility.

HYPOTHETICAL FOREST ROAD
(NOT UNREALISTIC)

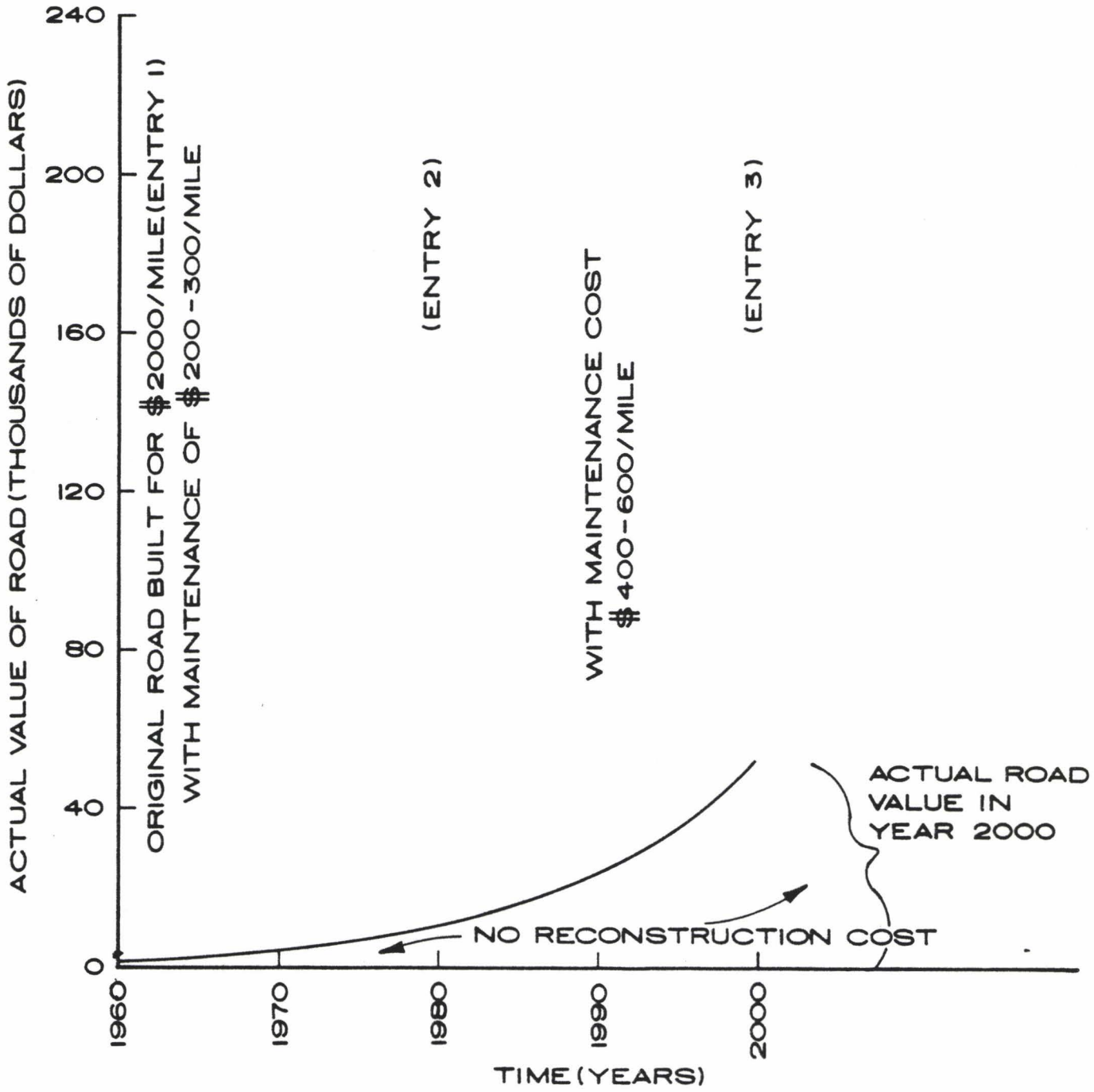


FIGURE 4.

F. Economics of Alternative Investment Maintenance Strategies

Going a step further, a cash flow of initial investment, maintenance and reconstruction costs can be established for various maintenance levels. Maintenance costs must be based on actual value of the facility. Using an initial cost of $2,000, reentry every 20 years, a base year of 1960, and maintenance and operation based on a percentage of actual year value, the cash flows of Table 3 were developed. These cash flows were discounted at 4 percent, 7 1/8 percent, and 10 percent and plotted in Figure 5. The relative costs of maintenance versus construction and reconstruction are shown in Figures 6, 7, and 8 for each discount rate. These plots indicate that minimum present value costs are achieved at maintenance levels of 3 percent of actual value of capital asset. The minimum occurs at 3 percent at both 4 percent and 7 1/8 percent discount rates. The minimum on the 10 percent discount rate curve occurs at 1 through 3 percent as the curve flattens out.

Real dollars were used to find the minimum present value cost. This is displayed in Table 4 and Figure 9. The differences in actual value are due to construction costs inflating faster than the CPI. The minimum occurs where maintenance is 2 percent of the actual value of the facility for this scenario.

If the 3 percent of actual value is used to evaluate maintenance requirements for Region 3 roads, an annual maintenance cost of $765,000,000 times 3 percent or $23,000,000. Two percent yields a $15,300,000 annual road maintenance budget.

TABLE 3. INITIAL COST, MAINTENANCE COST, RECONSTRUCTION COST CASH FLOWS

Initial Cost = $2,000 Entry = 20 years
*Twentieth Year Costs are Reconstruction.

Actual Value @8½%	Annual O&M and Reconstruction Costs as % of Actual Value						Year
	Fixed	1/2	1	2	3	4	1960
2,000	6	12	35	50	75	100	
2,500	7	15	30	60	90	120	
3,400	10	17	35	75	100	140	
4,000	11	20	40	80	120	160	
4,600	12	25	45	95	140	180	1970
5,500	15	30	55	110	170	220	
6,300	17	35	60	120	190	250	
7,400	20	40	75	160	220	300	
8,600	25	50	90	190	260	350	
10,000	10,000	8,000	5,000	3,000	1,000	500*	1980
11,700	30	60	110	230	350	470	
14,000	30	70	140	280	420	560	
17,900	35	90	180	350	540	720	
20,500	40	100	200	400	610	820	
23,400	50	120	240	460	700	940	1990
28,200	60	140	280	560	840	1,120	
33,400	70	160	330	660	1,000	1,330	
39,000	80	170	390	780	1,170	1,580	
44,500	90	190	450	900	1,330	1,800	
50,000	*50,000	40,000	25,000	15,000	5,000	2,500*	2000
PVC TOTAL							
@ 4%	17,400	14,900	11,400	10,400	9,400	10,600	
@ 7%	7,900	7,000	5,800	5,700	5,500	6,200	
@10%	4,700	4,400	3,900	3,950	4,000	4,500	
PVC CONSTRUCTION AND RECONSTRUCTION							
@ 4%	16,900	13,980	9,490	6,490	3,500	2,750	1960
@ 7 1/8%	7,700	6,570	4,860	3,710	2,570	2,290	
@10%	4,600	4,070	3,300	2,780	2,260	2,130	
PVC MAINTENANCE AND OPERATIONS							
@ 4%	500	920	1,910	3,910	5,900	7,850	1960
@ 7 1/8%	200	430	940	1,990	2,930	3,910	
@10%	100	330	600	1,170	1,740	4,070	

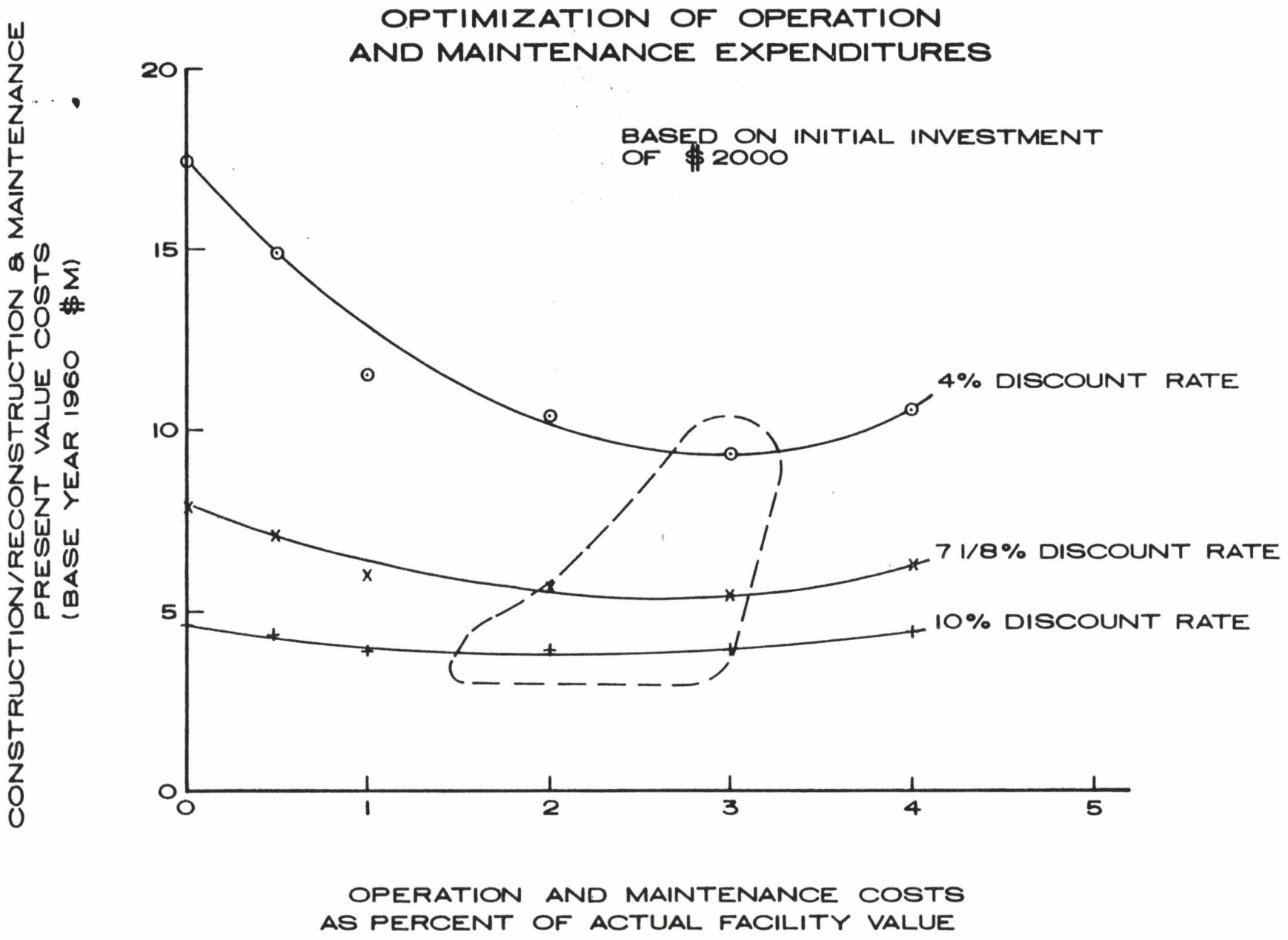

OPTIMIZATION OF OPERATION
AND MAINTENANCE EXPENDITURES
BASED ON INITIAL INVESTMENT
OF $2000
CONSTRUCTION/RECONSTRUCTION & MAINTENANCE
PRESENT VALUE COSTS
(BASE YEAR 1960 $M)
20
15
10
5
0
0
1
2
3
4
5
4% DISCOUNT RATE
7 1/8% DISCOUNT RATE
10% DISCOUNT RATE
OPERATION AND MAINTENANCE COSTS
AS PERCENT OF ACTUAL FACILITY VALUE

FIGURE 5.

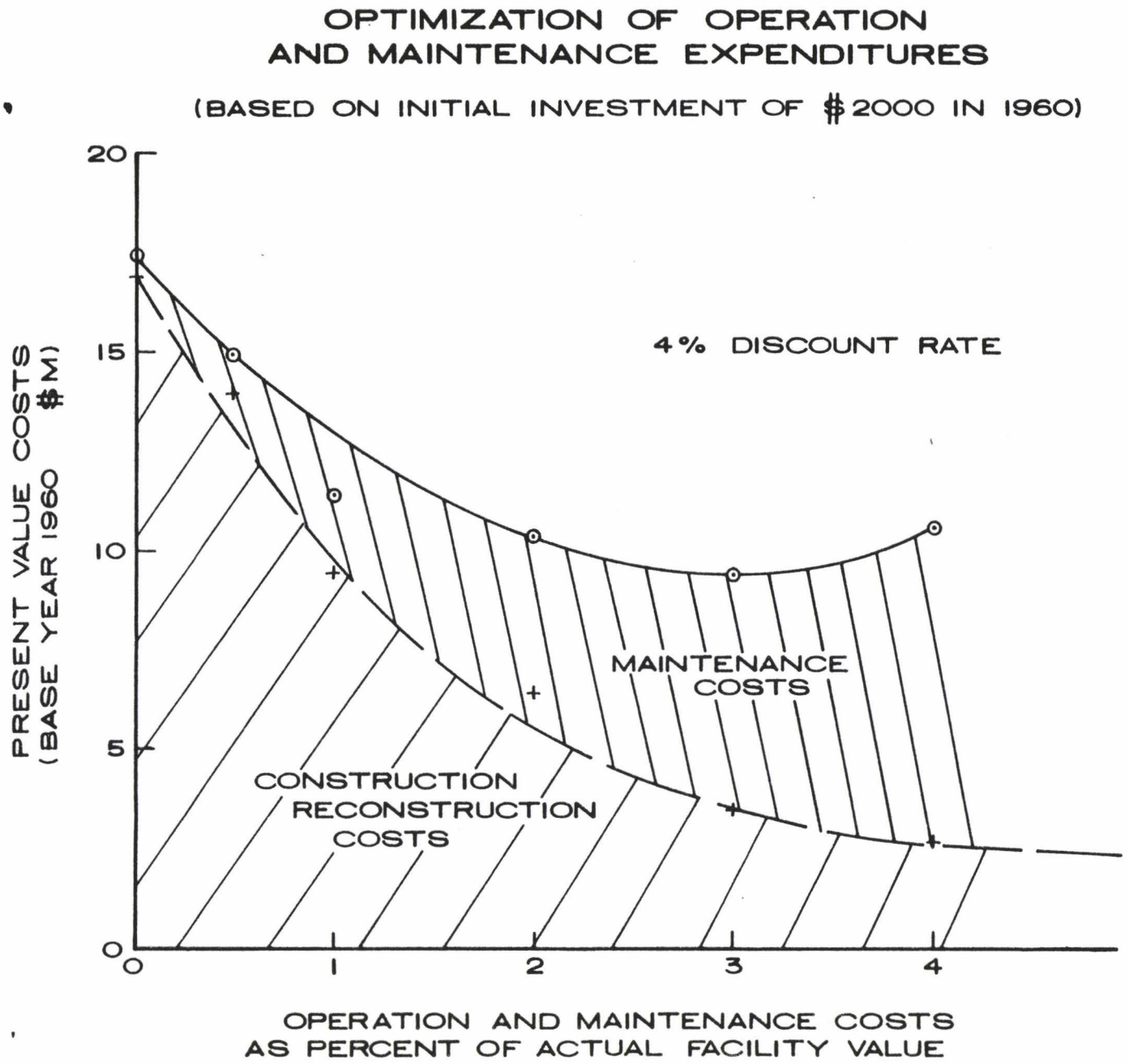

OPTIMIZATION OF OPERATION
AND MAINTENANCE EXPENDITURES
(BASED ON INITIAL INVESTMENT OF $2000 IN 1960)
4% DISCOUNT RATE
PRESENT VALUE COSTS
(BASE YEAR 1960 $M)
20
15
10
5
0
0
1
2
3
4
MAINTENANCE
COSTS
CONSTRUCTION
RECONSTRUCTION
COSTS
OPERATION AND MAINTENANCE COSTS
AS PERCENT OF ACTUAL FACILITY VALUE

FIGURE 6.

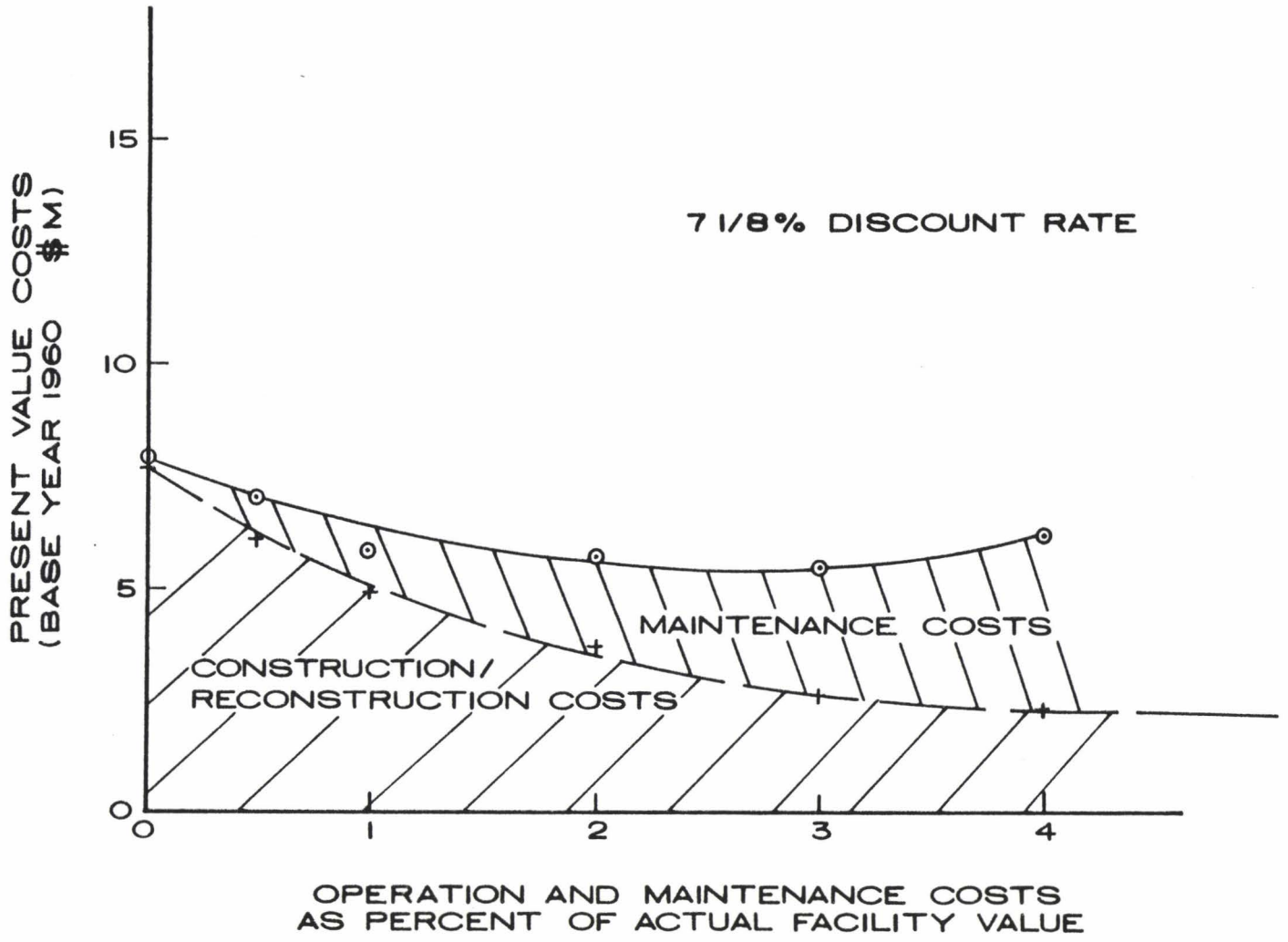

OPTIMIZATION OF OPERATION
AND MAINTENANCE EXPENDITURES
(BASED ON INITIAL INVESTMENT OF $2000 IN 1960)
7 1/8% DISCOUNT RATE
PRESENT VALUE COSTS
(BASE YEAR 1960 $M)
15
10
5
0
MAINTENANCE COSTS
CONSTRUCTION/
RECONSTRUCTION COSTS
0
1
2
3
4
OPERATION AND MAINTENANCE COSTS
AS PERCENT OF ACTUAL FACILITY VALUE

FIGURE 7.

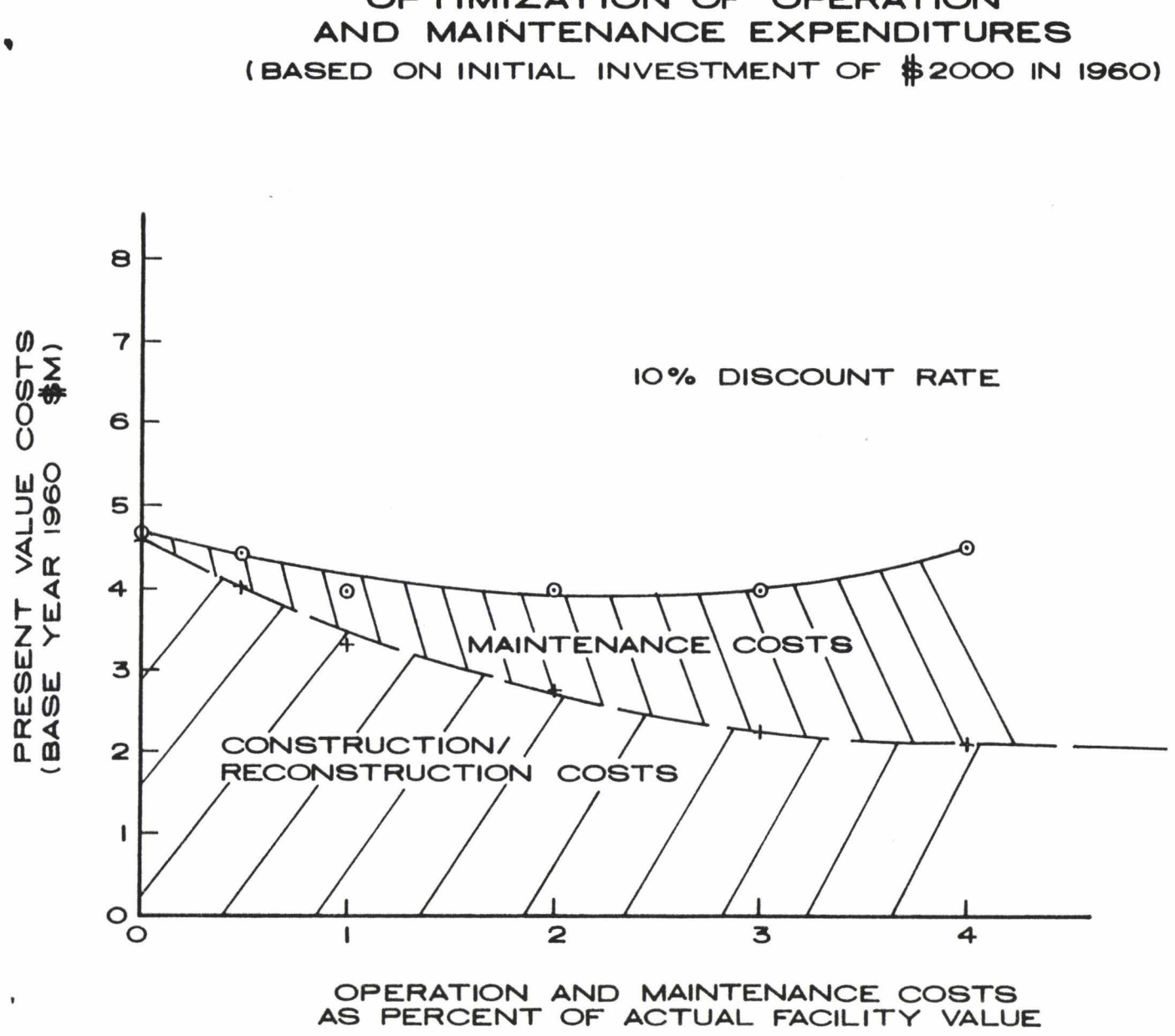

OPTIMIZATION OF OPERATION
AND MAINTENANCE EXPENDITURES
(BASED ON INITIAL INVESTMENT OF $2000 IN 1960)
10% DISCOUNT RATE
PRESENT VALUE COSTS
(BASE YEAR 1960 $M)
MAINTENANCE COSTS
CONSTRUCTION/
RECONSTRUCTION COSTS
0
1
2
3
4
5
6
7
8
OPERATION AND MAINTENANCE COSTS
AS PERCENT OF ACTUAL FACILITY VALUE

FIGURE 8.

TABLE 4 RECALCULATION OF TABLE 3
USING REAL DOLLARS WITH HEAVY
CONSTRUCTION INCREASING AT TWICE
THE STANDARD CONSUMER PRICE INDEX (Appendix D)

INITIAL INVESTMENT F.Y. 1960 =$2,000
* 20th YEAR COSTS ARE RECONSTRUCTION

ACTUAL VALUE	ANNUAL OPERATION AND MAINTENANCE COSTS AS % OF ACTUAL VALUE						YEAR
	Fixed	½	1	2	3	4	
2,000	6	12	22	44	66	88	1960
	7	14	28	56	84	112	1964
	8	16	32	64	96	128	1968
	9	18	36	72	108	144	1972
	10	20	40	80	120	160	1976
4,000	*4,000	*3,200	*2,200	*1,300	*500	*200	1980
	12	24	44	88	132	176	
	14	28	56	112	168	224	1984
	16	32	64	128	192	256	1988
	20	36	72	144	216	288	1992
	24	40	80	160	240	320	1996
8,000	*8,000	*6,400	*4,400	*2,600	*1,000	*400	2000
PVC @ 4%							
O&M	210	390	780	1,530	2,300	3,065	
Const/Reconst	5,490	4,795	3,920	3,135	2,435	2,175	
Total	5,700	5,185	4,700	4,665	4,735	5,240	
PVC @ 7%							
O&M	125	235	460	920	1,370	1,840	
Const/Reconst	3,570	3,255	2,860	2,510	2,195	2,080	
Total	3,695	3,490	3,320	3,430	3,565	3,920	
PVC @ 10%							
O&M	80	160	310	610	920	1,225	
Const/Reconst	2,770	2,615	2,425	2,250	2,095	2,040	
Total	2,850	2,775	2,735	2,860	3,015	3,265	

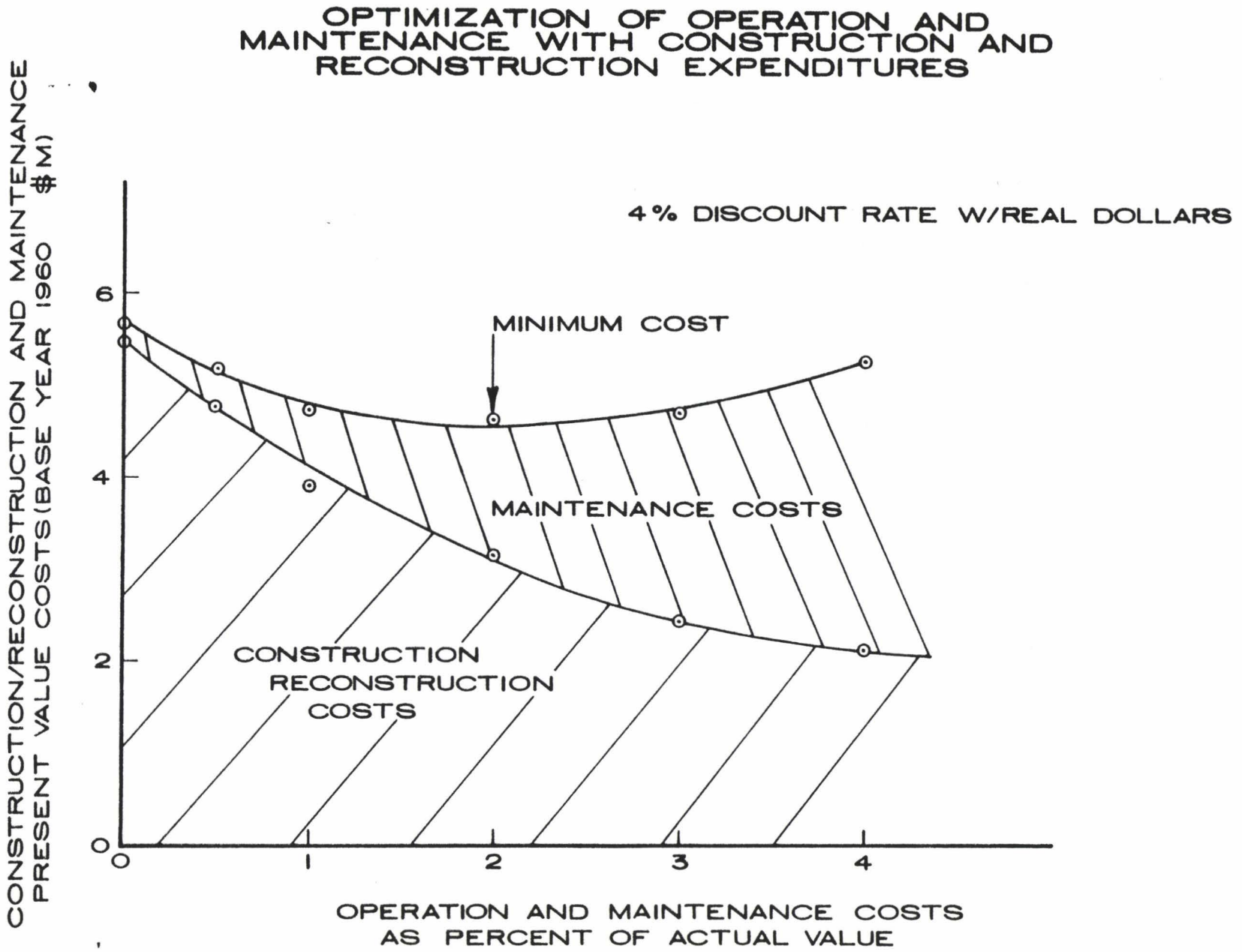

OPTIMIZATION OF OPERATION AND MAINTENANCE WITH CONSTRUCTION AND RECONSTRUCTION EXPENDITURES
4% DISCOUNT RATE W/REAL DOLLARS
CONSTRUCTION/RECONSTRUCTION AND MAINTENANCE PRESENT VALUE COSTS (BASE YEAR 1960 $M)
MINIMUM COST
MAINTENANCE COSTS
CONSTRUCTION RECONSTRUCTION COSTS
0
2
4
6
0
1
2
3
4
OPERATION AND MAINTENANCE COSTS AS PERCENT OF ACTUAL VALUE

FIGURE 9.

Salvage Value and Project life

The problem is complicated more when salvage value and project life are allowed to vary. The Washington Office created a Table 1 (see Table 5) where optimal annual maintenance expenditure is expressed as a percentage of original value. The assumption driving this table was "future reconstruction cost (FRC) equals original construction cost (OCC) minus salvage value (SV)" and "annual maintenance equals future reconstruction cost times the sinking fund factor." The sinking funding factor is that discounting factor that creates an equivalent annual rate for a future payment. These assumptions are quite good except "What is the future reconstruction cost and what is the salvage value?"

First, lets look at the future reconstruction cost in real dollars. The construction cost in 1980 is a factor of two times the original construction cost in 1960 in real dollars (see Appendix D). With that knowledge plus the laws of multiplication the real dollar factors that apply to construction for various project lives follow:

Project Life (years)	10	20	30	40
Factor	1.4	2.0	2.8	4.0

Secondly, the salvage value is negative with the significant increases in real dollars. Examples:

OCC = 2000, FRC = 3200

FRC = OCC - SV

$$SV = OCC - FRC$$
$$= 2000 - 3200$$
$$= 1200$$

How can this be handled using the original construction cost as a base? The formula as offered by the Washington Office can be modified by the factors indicated above

$$FRC = factor\ (OCC - SV)$$

The lower numbers in Table 5 are the optimal annual maintenance expenditures as percent of original construction cost. Figures 10, 11, and 12 are plots of the continuum of what annual maintenance costs can be spent to avoid reconstruction costs. Maintenance expenditures to the upper right of the curves are econonic for any proposed project life and salvage value.

It is obvious that discount rate, salvage value and project life are highly significant. Figure 10A indicates that in Region 3 where reconstruction costs are 80 percent of new construction, we could have expended over 5 percent annually for maintenance to offset that reconstruction cost (assuming the 4 percent discount rate). Figure 12A indicates 3 percent maintenance costs could be expended efficiently at 10 percent discount rate for the above Region 3 case.

This means that the efficient operation and maintenance level is 3 to 5 percent of the actual value of the facility. Figure 12B shows in the cross hatched areas the salvage values and project lives that are efficient at a 2 to 3 percent maintenance level with a discount rate of 10 percent.

TABLE - 1

ANNUAL MAINTENANCE EXPENDITURE AS % OF ORIGINAL VALUE

SALVAGE VALUE %		n = 10 YEARS INTEREST RATE			n = 20 YEARS INTEREST RATE			n = 30 YEARS INTEREST RATE			n = 40 YEARS INTEREST RATE		
		1=4%	i=7%	i=10%	i=4%	i=7%	1=10%	i=4%	i=7%	i=10%	i=4%	i=7%	i=10%
100	1/	0	0	0	0	0	0	0	0	0	0	0	0
	2/	0	0	0	0	0	0	0	0	0	0	0	0
80	1/	1.7	1.4	1.3	0.7	0.5	0.4	0.4	0.2	0.1	0.2	0.1	0.05
	2/	2.3	2.0	1.8	1.3	1.0	.7	1.0	.6	0.3	0.8	0.4	0.2
60	1/	3.3	2.9	2.5	1.3	1.0	0.7	0.7	0.4	0.2	0.4	0.2	0.09
	2/	4.7	4.0	3.5	2.7	2.0	1.4	2.0	1.2	0.7	1.7	0.8	0.4
40	1/	5.0	4.3	3.8	2.0	1.4	1.1	1.1	0.6	0.4	0.6	0.3	0.14
	2/	7.0	6.1	5.3	4.0	2.9	2.1	3.0	1.8	1.0	2.5	1.2	0.5
20	1/	6.7	5.8	5.0	2.7	1.9	1.4	1.4	0.8	0.5	0.8	0.4	0.18
	2/	9.3	8.1	7.0	5.4	3.9	2.8	4.0	2.4	1.4	3.4	1.6	0.7
0	1/	8.3	7.2	6.3	3.4	2.4	1.8	1.8	1.0	0.6	1.1	0.5	0.23
	2/	11.7	10.1	8.8	6.7	4.9	3.5	5.0	3.0	1.7	4.2	2.0	0.9

Based on: $A = F \frac{i}{(1+i)^{n}-1}$ Where: A = Annual Payments
F = Future Reconstruction Cost
i = Interest Rate
n = Number of Years

Assumption: 1/ Future reconstruction cost = Original Construction Cost - Salvage Value
2/ Future reconstruction cost = *Factor (Original construction cost - Salvage Value)
based on Heavy Construction Consumer price index versus C.P.I.

* Factor for project life (years)	10	20	30	40
(To adjust for heavy construction CPI) Factor	1.4	2.0	2.8	4.0

REAL DOLLARS EQUIVALENT RECONSTRUCTION COST TO OPERATION AND MAINTENANCE LEVEL AS PERCENTAGE OF ORIGINAL CONSTRUCTION COST AT 4% DISCOUNT RATE

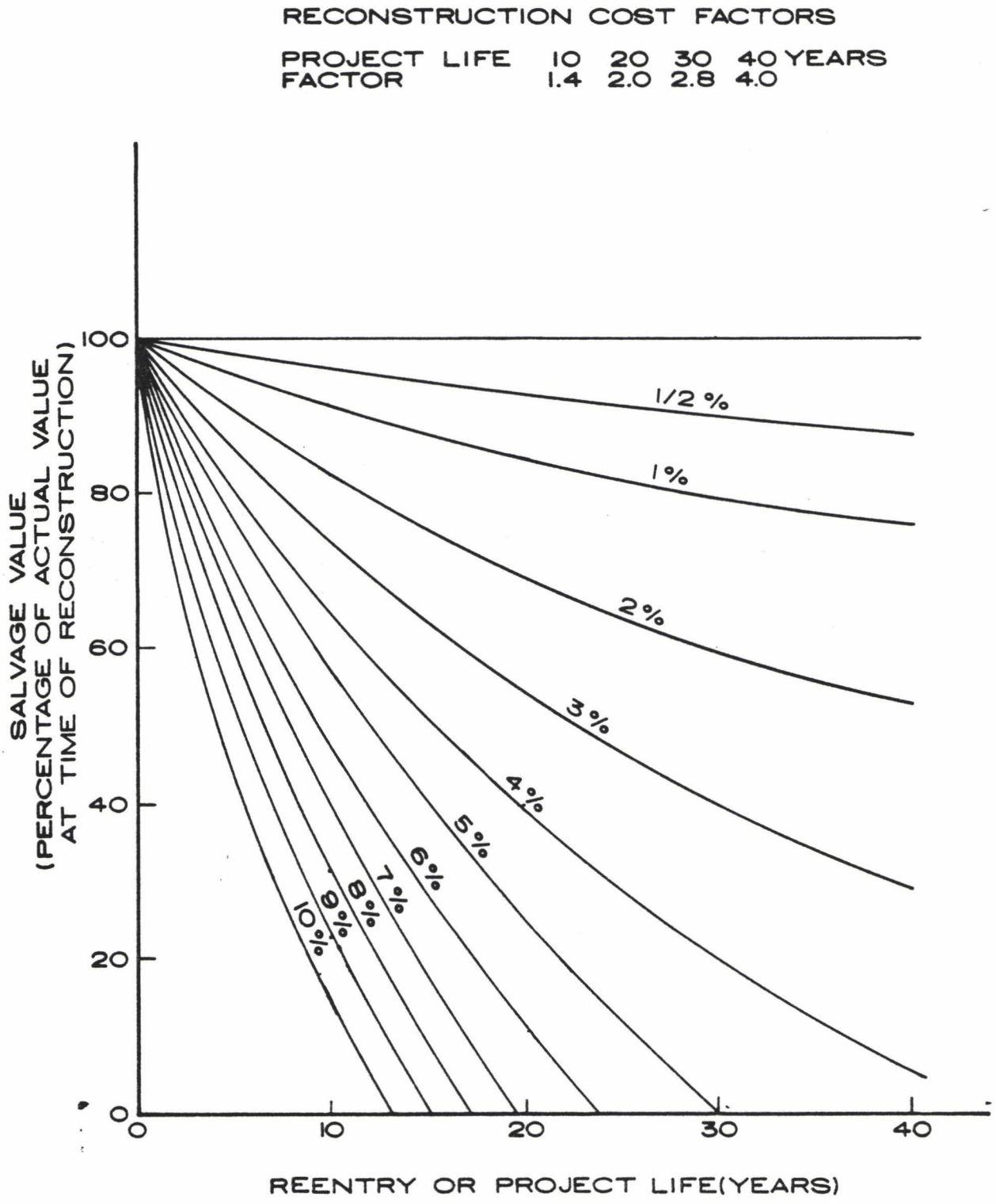


FIGURE 10.

REAL DOLLARS EQUIVALENT RECONSTRUCTION VALUE COST TO ANNUAL OPERATION AND MAINTENANCE COST AS PERCENT OF ORIGINAL CONSTRUCTION COST AT 7% DISCOUNT RATE

RECONSTRUCTION COST FACTORS

PROJECT LIFE	10	20	30	40 YEARS
FACTOR	1.4	2.0	2.8	4.0

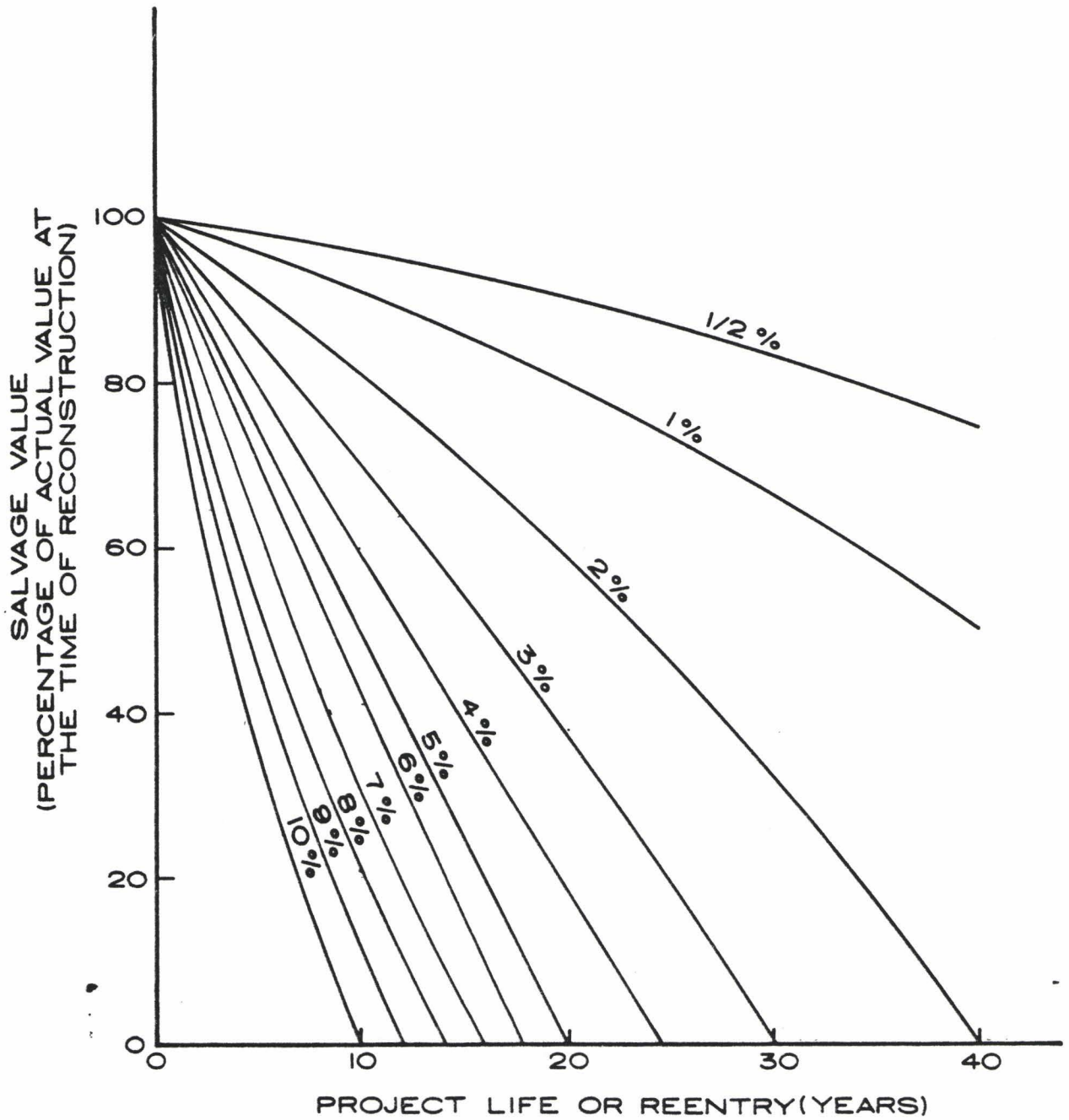


FIGURE 11.

REAL DOLLARS EQUIVALENT RECONSTRUCTION PRESENT VALUE COST TO ANNUAL OPERATIONS AND MAINTENANCE COST — MAINTENANCE EXPRESSED AS % OF ORIGINAL COST AT 10% DISCOUNT RATE

RECONSTRUCTION COST FACTORS

PROJECT LIFE	10	20	30	40 YEARS
FACTOR	1.4	2.0	2.8	4.0

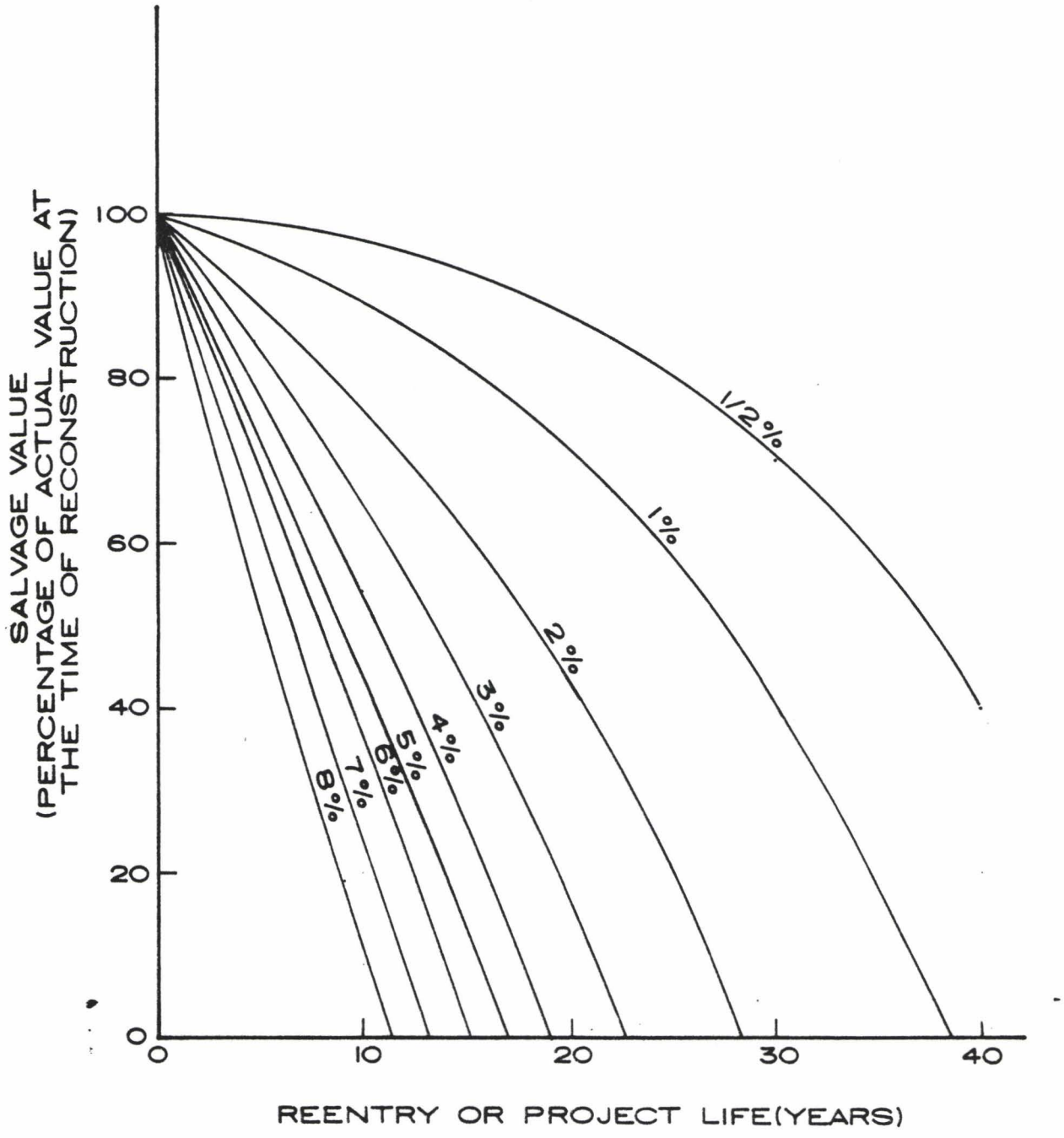


FIGURE 12.

REAL DOLLARS EQUIVALENT RECONSTRUCTION COST TO OPERATION AND MAINTENANCE LEVEL AS PERCENTAGE OF ORIGINAL CONSTRUCTION COST AT 4% DISCOUNT RATE

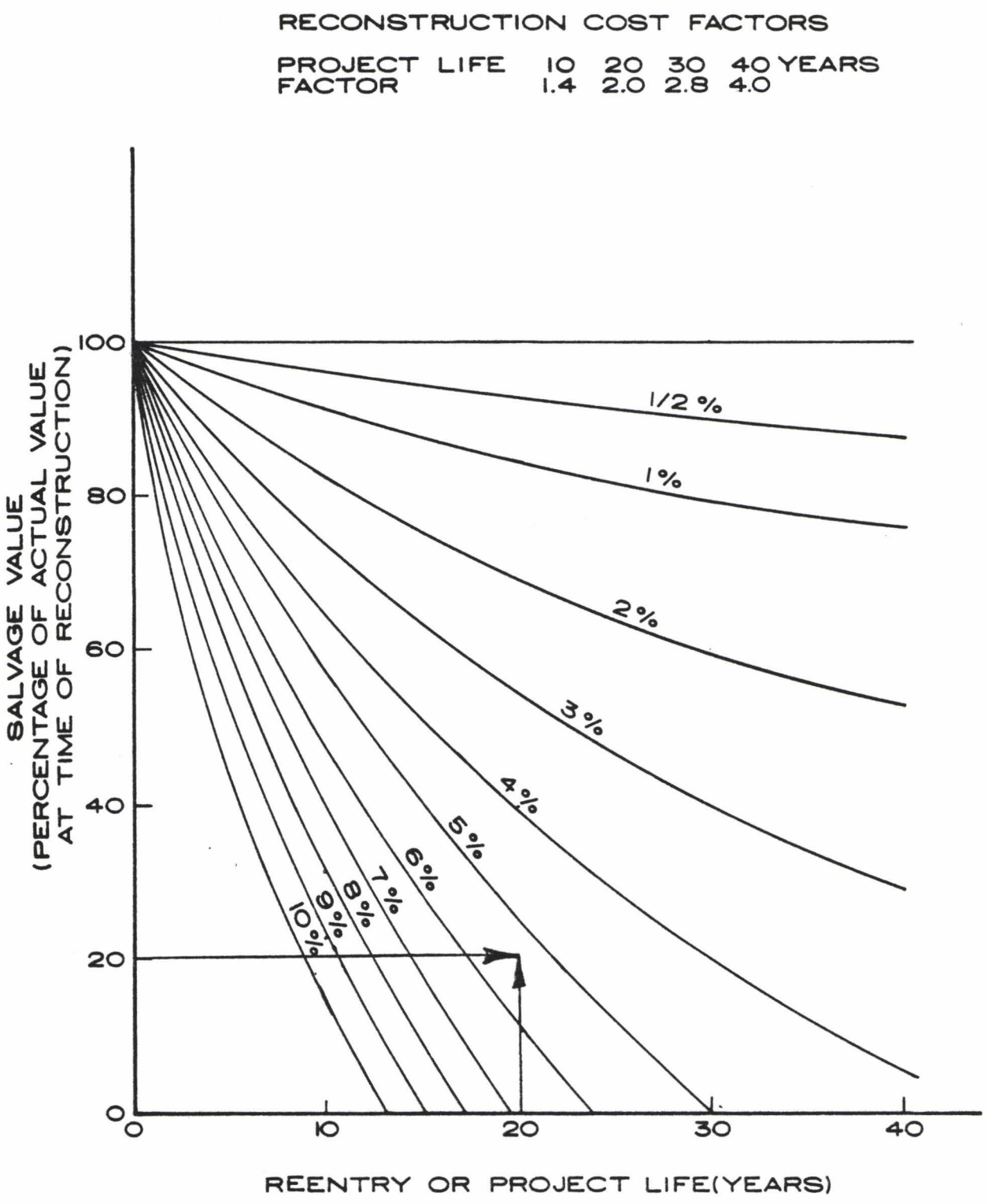


FIGURE 10A

REAL DOLLARS EQUIVALENT RECONSTRUCTION PRESENT VALUE COST TO ANNUAL OPERATIONS AND MAINTENANCE COST — MAINTENANCE EXPRESSED AS % OF ORIGINAL COST AT 10% DISCOUNT RATE

RECONSTRUCTION COST FACTORS

PROJECT LIFE	10	20	30	40 YEARS
FACTOR	1.4	2.0	2.8	4.0

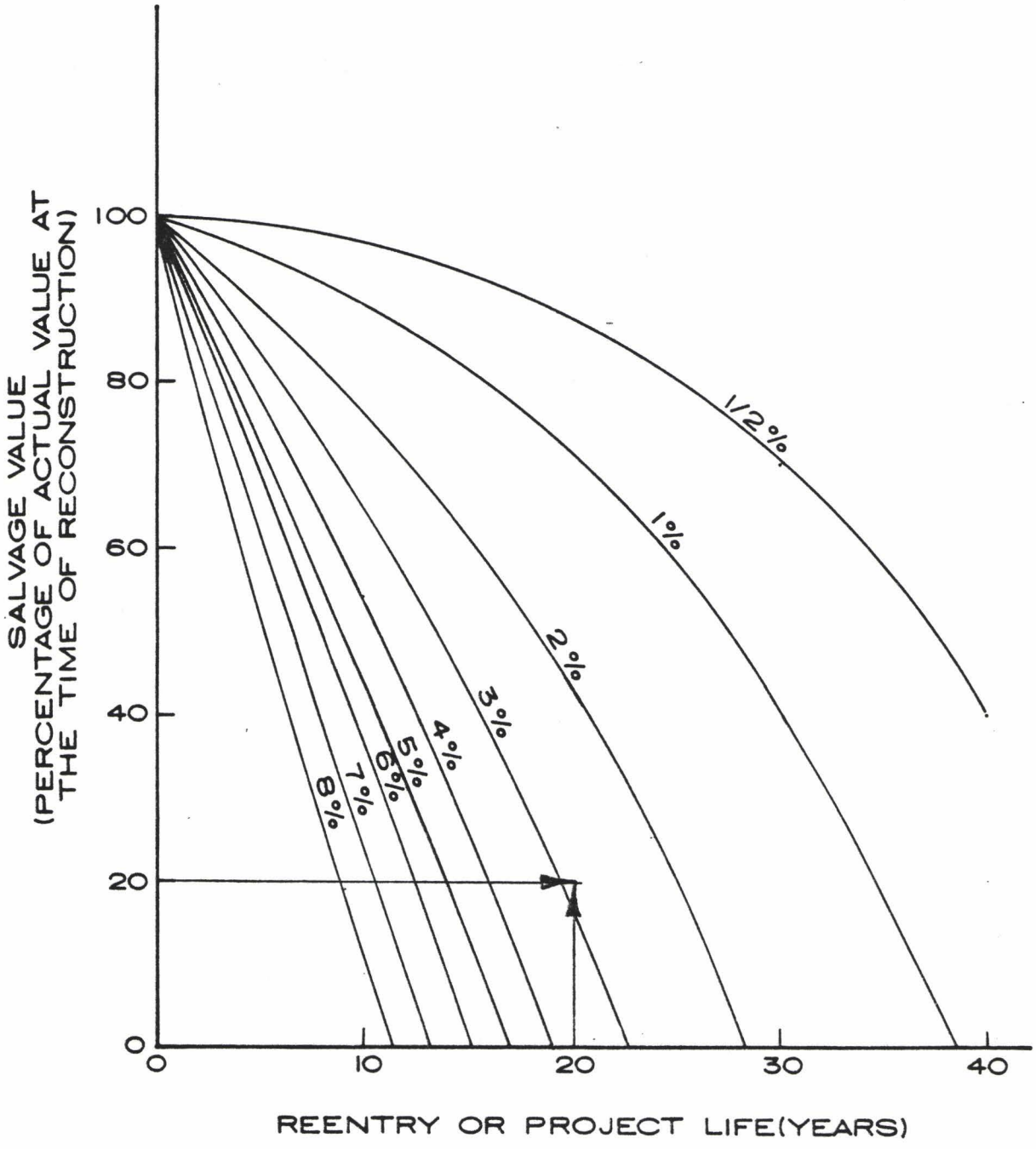


FIGURE 12A

REAL DOLLARS EQUIVALENT RECONSTRUCTION PRESENT VALUE COST TO ANNUAL OPERATIONS AND MAINTENANCE COST — MAINTENANCE EXPRESSED AS % OF ORIGINAL COST AT 10% DISCOUNT RATE

RECONSTRUCTION COST FACTORS

PROJECT LIFE	10	20	30	40 YEARS
FACTOR	1.4	2.0	2.8	4.0

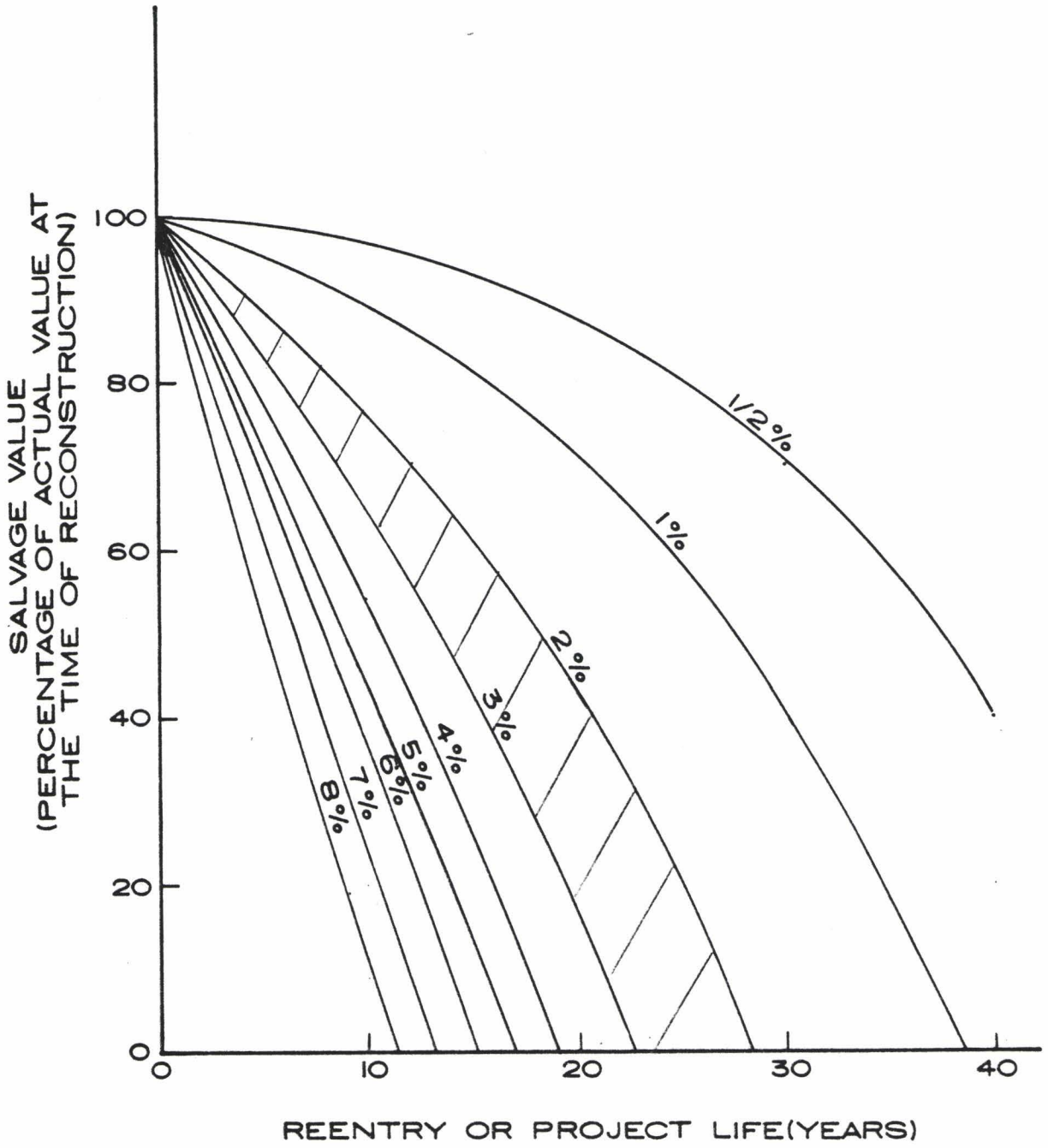


FIGURE 12B

V. ALTERNATIVES

A. Current Management. This alternative would continue current maintenance levels at 1/2 percent of actual facility values. This means many roads will be reconstructed every 20 years at 80 percent of actual value. Sedimentation and surface loss from existing roads and trails will be excessive requiring replacement. The aggregate (non-renewable) resource will be utilized and replacement costs will soar as haul distances become greater and greater.

B. Trend maintenance levels to the 2 to 3 percent level. This alternative would minimize present value of costs for facilities. It would preserve the transportation resource for future efficient use, minimize user costs (not previously addressed in this paper), reduce the dusting of the vegetative and wildlife resources adjacent to the transportation systems.

The budgeting of this alternative would be difficult in the early years for maintenance. It is easier to get road purchaser credit to rebuild than to get maintenance dollars to preserve the investment.

C. Close 50 percent of existing roads to reduce maintenance needs to the 1 1/2 to 2 percent maintenance level. Initial costs of closures would make this alternative difficult in the early years. Physical and biological advantages would be similar to alternative B. Social consequences would be great as the public loses access to much of the land base. Seasonal closures to avoid wet weather access would be more acceptable to some of the public.

VI. ANALYSIS AND EVALUATION OF ALTERNATIVES

	Alternative Consequences		
CONCERN	A	B	C
PHYSICAL AND BIOLOGICAL			
Soil and Water	Continued Erosion	Erosion will be controlled	Same as B
Flood Hazards	Continued flood potential	Reduced significantly	Reduced significantly not as good as "B"
Atmospheric Quality	Continued dusting of adjacent environment	Increased quality less dusting	Same as "B"
Waterlife and Plantlife	No change	Reduced dusting of the adjacent environment will occur	Same as B, except reduced harrassement of fish and wildlife will also occur
Physical Features	No change	Erosion reduction will slow radical changes due to flooding	Same as "B"

	A	B	C
Energy	No change	Major reduction in user fuel consumption	Same as "B" only greater fuel reduction
Esthetics	No Change	Improved esthetics due to ability to view without road hazards	Same as "B" but less access some areas
Ecological	No change	Increased productivity adjacent to roads	Increased productivity of plants, animals, and waterlife
SOCIAL			
Special Group Access	No change	Improved access	Less access
Minority Group Impact	No change	No change	Adverse impact to local residents, hunters, fishers, ORV users

	A	B	C
Political	No change	Upgrading roads could create conflicts	Closing roads could be adverse
Recreational Opportunities	No change	Improved access will be positive	Some positive with improved major roads, local road closures cut access to some recreational users
Capital Economics	No change	Significant reduction in present value costs (PVC)	Significant reduction in PVC (more than B)
Financial	No change but longer term re-construction costs will remain high	Increased near term maintenance costs but significant reduction in long term reconstruction costs	Same as "B" but long-term main-tenance costs would be reduced further

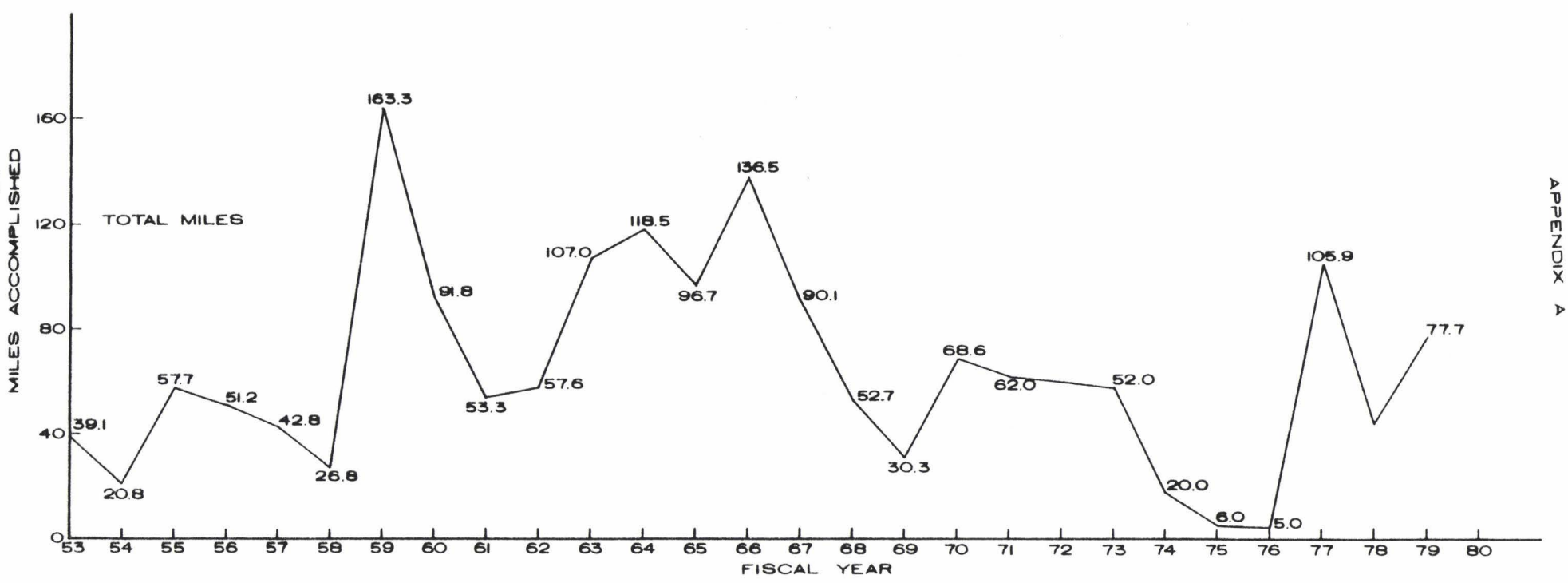
VII. SUMMARY

Region 3's maintenance budgets are too low for efficient useage of public funds. Expenditures for maintenance are currently at the 1/2 percent of actual value level. Analysis of maintenance and reconstruction costs indicates 2 to 3 plus percent is the most cost efficient level for operation and maintenance. Significant variables in this analysis are discount rate, salvage value, and project life. Figures 10, 11, and 12 show the relationships of maintenance levels as a function of salvage value, project life, and discount rate.

APPENDIXES

ROAD CONSTRUCTION/RECONSTRUCTION ACCOMPLISHMENT

(NO LONGER REPORTED AS TIMBER ACCESS & ALL PURPOSE)

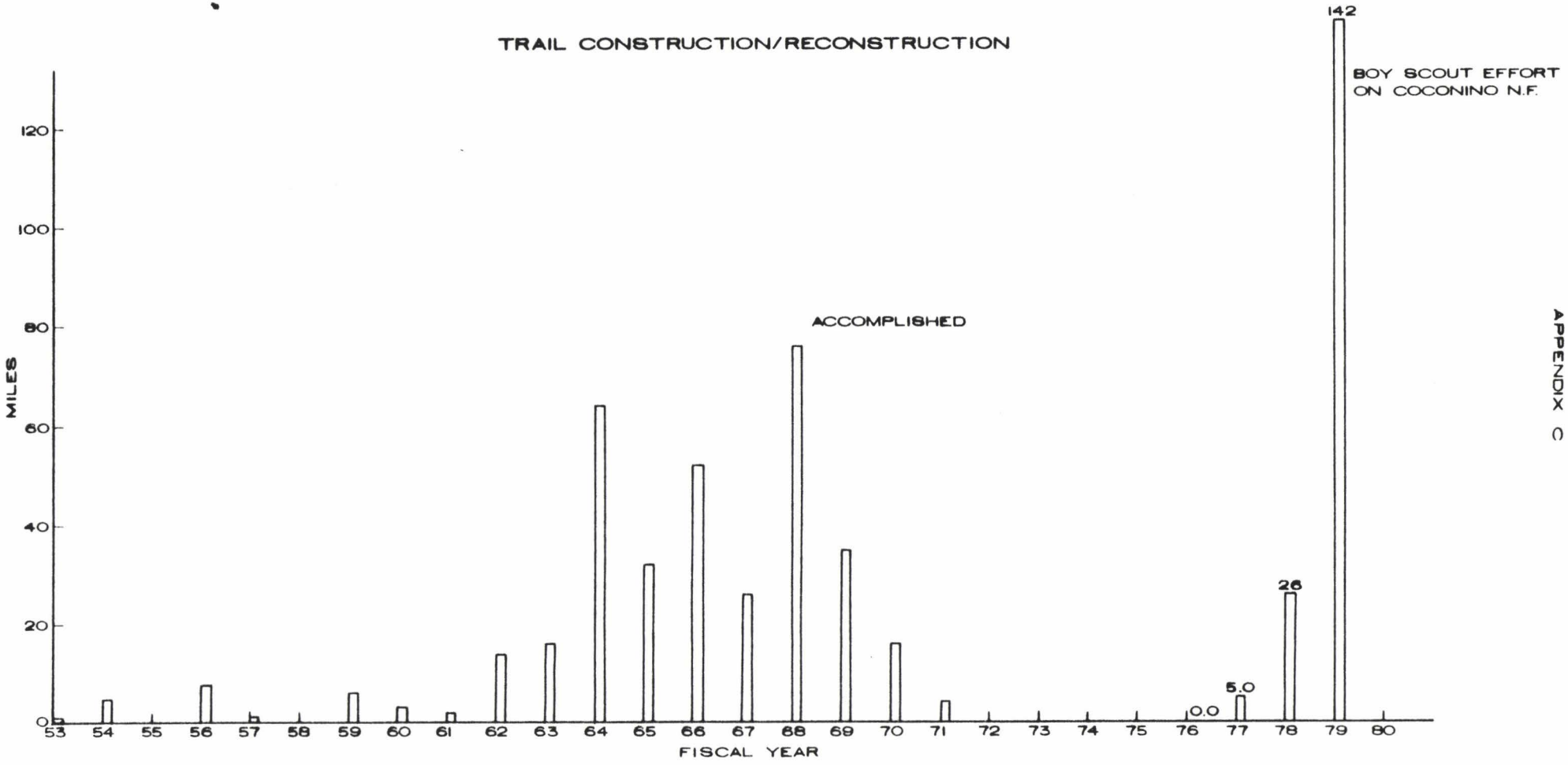


APPENDIX B

REGION 3 ROAD STATISTICS FOR SOLD TIMBER SALES

Time Period	No. Sales	Volume MMBF	SPECIFIED ROADS C Miles	SPECIFIED ROADS R Miles	SPECIFIED ROADS Total Const. & Reconst.	Temporary Roads Miles	Total Road Miles Spec + Temp	Miles/MM Spec	Miles/MM Temp	Miles/MM Spec + Temp	Purch. Credit M $	Specified Road Cost Per Mile
Cal 72		386	240		240	960	1,200	0.62	2.49	3.11		
FY 73		330	211.8		211.8	805	1,016.8	0.64	2.44	3.08		
FY 74	60	300	39	129.4	168.4	518	686.4	0.56	1.73	2.29	2,621	15,564
Cal 74	47	204	11.8	90.0	101.8	365	466.8	0.50	1.79	2.29	1,722	16,915
Cal 75	54	323	49.4	143.4	192.8	858	1,050.8	0.60	2.66	3.25	2,327	12,070
FY 75	53	301	23.6	121.0	144.6	721	865.6	0.48	2.40	2.88	2,146	14,841
FY 76	63	306	76.4	151.1	227.5	788	1,015.5	0.74	2.58	3.32	2,433	10,695
Interim 7/1/76 - 9/30/76		51	20.2	35.3	55.5	52	107.5	1.09	1.02	2.11	354	6,378
FY 77	52	242	97.3	227.0	324.3	269	593.3	1.34	1.11	2.45	2,155	6,645
Cal 77	55	257	128.5	243.8	372.3	270	642.3	1.45	1.05	2.50	2,569	6,900
1st 1/2 FY 78	20	122	82.9	168.9	252.8	84	335.8	2.07	.69	2.93	1,779	7,040
FY 78 (Planned)	53	329	708.5		708.5			2.15			6,518	9,200
(Actual)	70	335	188.6	482.4	671.0	320	991.0	2.00	.96	2.96	6,032	8,989
FY 79 (Planned)		345	605		605			1.75			4,437	8,160
(Actual)	78	314.1	202.9	467.4	670.3	416.2	1086.5	2.13	1.33	3.46	*10,114	15,089
FY 80 (Planned Current)		320	724		724			2.26			4,668	6,448
FY 81 RPA Alt. 1		362	634		634			1.75			5,200	8,781
FY 81 RPA Alt. 2		327	497		497			1.52			5,200	7,604
FY 81 RPA Alt. 3 (Current)		360	457		458			1.27			5,200	9,504
FY 81 RPA Alt. 4		340	523		523			1.54			5,200	7,797
FY 81 RPA Alt. 5		360	603		603			1.68			5,200	8,496

*Includes $1,080,253 for five opted sales. Actual PC = $9,033,660


TRAIL CONSTRUCTION/RECONSTRUCTION
ACCOMPLISHED
BOY SCOUT EFFORT
ON COCONINO N.F.
142
28
5.0
0.0
MILES
0
20
40
60
80
100
120
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
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71
72
73
74
75
76
77
78
79
80
FISCAL YEAR

APPENDIX D

Consumer Price Indices 1960-1980

Year	CPI All Hems		Heavy Construction	
	57-59 base	57-59 base	57-59 base	57-59 base
1960	103.1	103.1	108.4	108.4
1961	104.2	104.2	111.5	111.5
1962	105.2	105.2	114.7	114.7
1963	106.7	106.7	118.6	118.6
1964	108.1	108.1	123.5	123.5
1965	109.9	109.9	127.8	127.8
1966	113.1	113.1	133.4	133.4
1967	116.3	116.3	140.8	140.8
1968	121.2	121.2	151.9	151.9
	1967-69 base		1967-69 base	
1969	109.8	133.0	118.7	180.3
1970	116.3	140.8	128.9	195.3
1971	121.3	146.9	146.7	222.3
1972	125.3	151.7	163.0	247.5
1973	133.1	161.2	176.5	268.1
1974	147.7	178.9	188.0	285.6
1975	161.2	195.2	205.7	312.5
1976	170.5	206.5	223.4	339.3
1977	181.5	219.8	240.0	364.6
1978	195.3	236.5	258.4	392.5
1979 Est.	218.3	264.4	280.0	425.3
1980 Est.	230.0	278.0	320.0	486.1
1981 Est.	245.0	296.0	350.0	531.6
1982 Est.	260.0	315.0	380.0	577.2

Reference: Survey of Current Business, Bureau of Economic Analysis, U.S. Department of Commerce.